dr hab Alex Markowitz
Summary of the presentation for the Scientific Council of CAMK
"Determining Accretion Flows in Seyfert Active Galactic Nuclei"
29.11.2019

Since my arrival at CAMK in January 2017, I have been developing a small group containing 3rd-year PhD student Ms. Saikruba Krishnan and 1st-year PhD student Mr. Tathagata Saha; we have been collaborating closely with Prof. Alex Schwarzenberg-Czerny, who is formal supervisor for Ms. Krishnan and Mr. Saha until my habilitation is conferred.

I am the PI of two NCN grants: an NCN-OPUS grant (Oct. 2017 through Jul. 2020) and the PI of an NCN-BEETHOVEN CLASSIC bilateral grant with Germany (Deutsche Forschungsgemeinschaft; Jan. 2020 – Dec. 2022).

Prior to my arrival at CAMK, I was supported by various grants at the Univ. of California, San Diego, Center for Astrophysics and Space Sciences. These include a NASA-ADAP grant (with me as PI) to trace circumnuclear matter via absorption-variability in type II Seyferts; it supported a post-doctoral research at UCSD (Dr. Sibasish Laha) through May 2019, and the grant will terminate in 2020.

My research focuses on compact accreting objects, primarily Active Galactic Nuclei (AGN); my collaborators and I use X-ray timing and spectroscopy to infer the morphology of accreting matter across scales of gravitational radii to parsecs, AGN duty cycles and black hole (BH) feeding, and AGNs' impact on their host galaxies via mechanical/radiative feedback. I focus mainly on detailed studies of nearby, radio-quiet Seyferts, but have also studied accreting/ejection processes in radio-loud AGN and X-ray Binaries. Here at CAMK, I can consequently contribute to the institute's observational astronomy and high-energy astrophysics components.

Current/near-future activity: Assessing periodic signals in AGN: Our group is focused on AGN continuum variability analysis, which can trace structures and physical processes in the inner accretion disks of black holes, including in the regime of extreme gravity. Current or future large-area ground-based observing programmes such as PanSTARRS, PTF, or LSST provide bulk monitoring of flux variability in 10^{3-6} AGN. Based on trawls of quasar optical lightcurve databases, some authors have already claimed to detect periodic signals and interpreted them as evidence for supermassive black holes *binaries* (SMBHBs) — potential sources of gravitational wave emission. However, most claims are likely the product of stochastic "red noise" from single-BH accretion, with improperly calibrated false alarm probabilities.

Thanks to the NCN-OPUS grant (Fall 2017 through Summer 2020), Ms. Krishnan, Prof. Schwarzenberg-Czerny, and I are empirically evaluating the efficacy of several statistical methods in detecting periodicities when red noise due to disk accretion is present, and estimating regions of system parameter space (masses, binary separations) where SMBHBs can or cannot reasonably be detected based on variability. Our guidance can be applied to QPO claims resulting in bulk searches of AGN, can guide the community in producing only statistically-significant QPO claims, and can constructively guide assessment of various interpretations of periodicities (SMBHBs, jet precession).

Next $\sim$ 1–4 years: studying changing-look AGN with eROSITA: Fueling mechanisms in AGN remain poorly understood, but recent clues have come courtesy of observations of rare accretion ignition/depletion events, and variations in line-of-sight column density due to transiting discrete clumps.

The NCN-BEETHOVEN CLASSIC grant will support work done by Mr. Saha, Ms. Krishnan, and myself to work in collaboration with members of eROSITA time domain analysis and AGN working groups (I am in the process of becoming an eROSITA External Collaborator), including Prof. Dr. Joern Wilms (Remeis/ECAP/FAU) and Dr. Mirko Krumpe (AIP). We will use machine learning to perform bulk X-ray identification of new transients with eROSITA, including catching new AGN accretion ignition/depletion events and major changes in line-of-sight circumnuclear gas as they occur. In particular, the PhD students will be involved in multi-wavelength followups to monitor how the disk, Broad Line Region, and corona evolve during rapid changes in global accretion rate, and to determine the physical properties of occulting clouds.

Our work will yield the first X-ray observation-based estimate for AGN duty cycles, and constrain how quickly the accretion flow can evolve in AGN ignition events. We will also know better the distribution of

clumpy matter and the rate of observed obscuration transitions, helping us understand X-ray/optical type mismatches. Our work also sets the stage for additional Big Data research in the mid-2020s that also use machine learning to classify transients.

Up to $\sim$ 5 **years and beyond:** From now through the foreseeable future, my group will continue to enhance CAMK's observational astronomy component: we will continue to particpate in new guest observer observations of AGN using current missions (e.g., *XMM-Newton*, *NuSTAR*, *AstroSAT*), while preparing to participate in X-ray observations using to-be launched X-ray telescopes such as *ATHENA*, *XRISM*, and *eXTP* (expected launch dates 2032, $\gtrsim$ 2021, and 2025 respectively). These next-generation, high-effective area and/or high-energy resolution telescopes will allow the most detailed studies of Fe Kα line emission profiles to date, enabling us to trace with unprecedented precision the morphology of the dusty torus and the inner accretion disk, to trace black hole spin, and to test the latest generations of clumpy-torus models.

I plan to work with up to $\sim$ 2 – 3 additional PhD students at a time after Ms. Krishnan and Mr. Saha each complete their PhD programs.

I aim to continue continue to co-author papes with (and hopefully co-I or PI grants with) others at CAMK who study accreting black holes e.g., Andrzej Zdziarski, Agata Różańska, and Barbara De Marco, as well as with other external, long-term collaborators such as S. Vaughan (Univ. of Leicester), J. Reeves (Univ. of Maryland Baltimore County), J. Wilms (Remeis/RCAP/FAU), and AGN researchers at Jagiellonian University Astronomical Observatory.